# Decision Support for Managing Wildland Fire Risk

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# CONTEXT

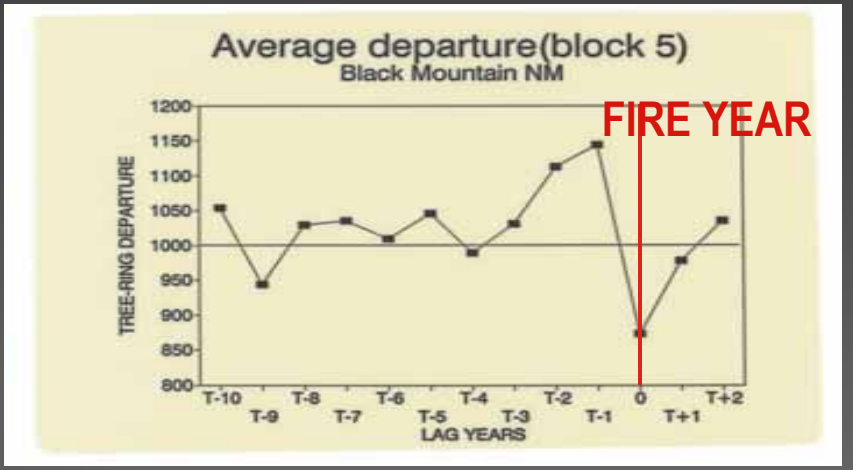
- High Wildland Fire Risk
  - 211 million acres in deteriorating condition (GAO)
  - Increase in acres burned and in costs
- Federal Interest in Fostering Use of Climate Information
  - El Niño/La Niña; Pacific Decadal Oscillation
- Emphasis on Interdisciplinary & Integrated Research
  - Address problems important to society

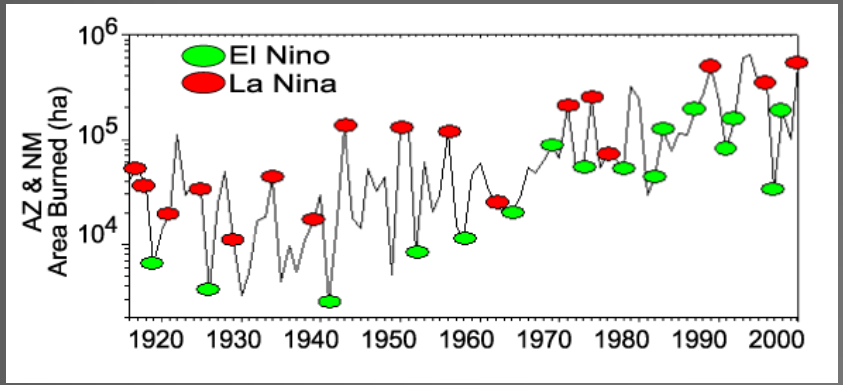
# Science for Decision Support

- Integration of science and practical knowledge
  - Interdisciplinary academic expertise
  - Societal expertise and experience
- Collaboration
  - Active stakeholder participation
- Iteration
  - Sustained interaction and experimentation

# Climate Drivers

- Emergence of El Niño-Southern Oscillation forecast capabilities
- Scientific advances in correlating ENSO and wildland fire in SE, SW NW
- Climate-related opportunity: El Niño winter followed by La Niña winter
- Dry conditions in key areas

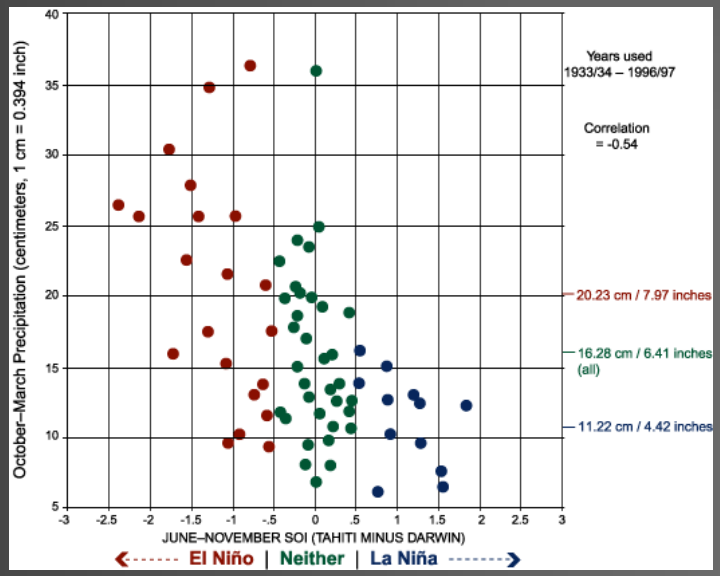


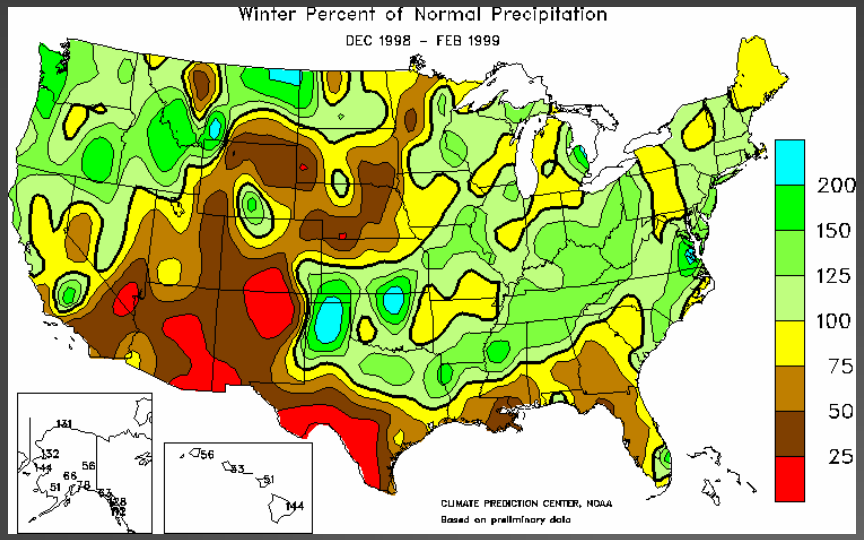

Graphs courtesy of UA Tree-Ring Lab

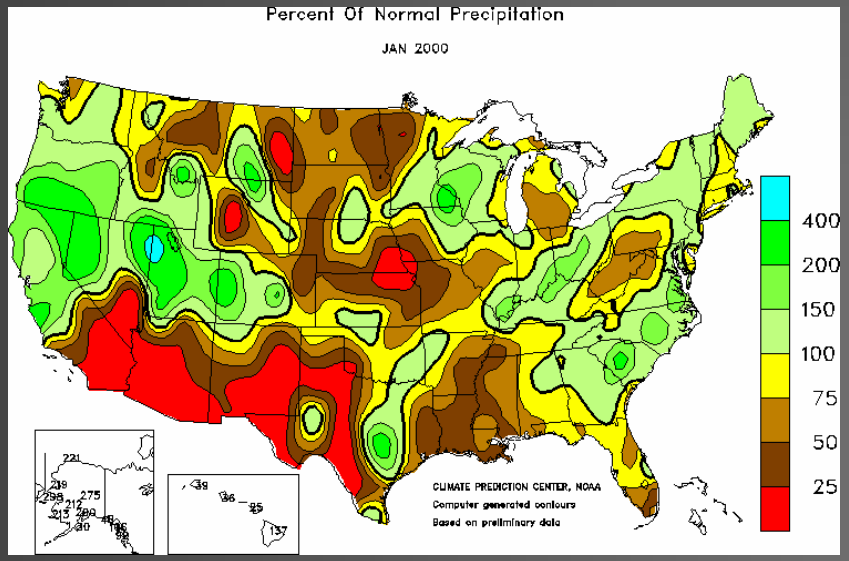
# Climate Forecasts

- ENSO forecasts are now fairly dependable
- Close link with regional fire regimes
- ENSO-related variability provides clues about potential impacts of climate change



# Winter 1998-1999, 1999-2000




Maps: NOAA Climate Prediction Center

# Fire-Climate Workshops

- Initiated out of concern about heightened fire risk due to climatic conditions
- Introduced climatologists/fire ecologists & fire managers/fuel managers to each other
- Stimulated dialogue about usefulness of climate information for wildland fire management

# Key Workshop Recommendation

- Develop tools that integrate climate into planning and decision making
  - Climate-fire regime modeling tools

# Fire-Climate-Society GIS Model: FCS-1

- Direct response to Fire-Climate Workshop outcomes
  - Climate Assessment for the Southwest (NOAA-OGP)
- 3-1/2 year project
  - 2000-2004
- Goal = build integrated GIS model for strategic planning
- Interdisciplinary, collaborative, iterative

# Features

- Designed for strategic planning – *not* tactical operations
- 1-kilometer square resolution
  - Finest scale possible for climate information
- Focus is on fires >250 acres
- Designed for use by both experts and non-experts
- Web-based

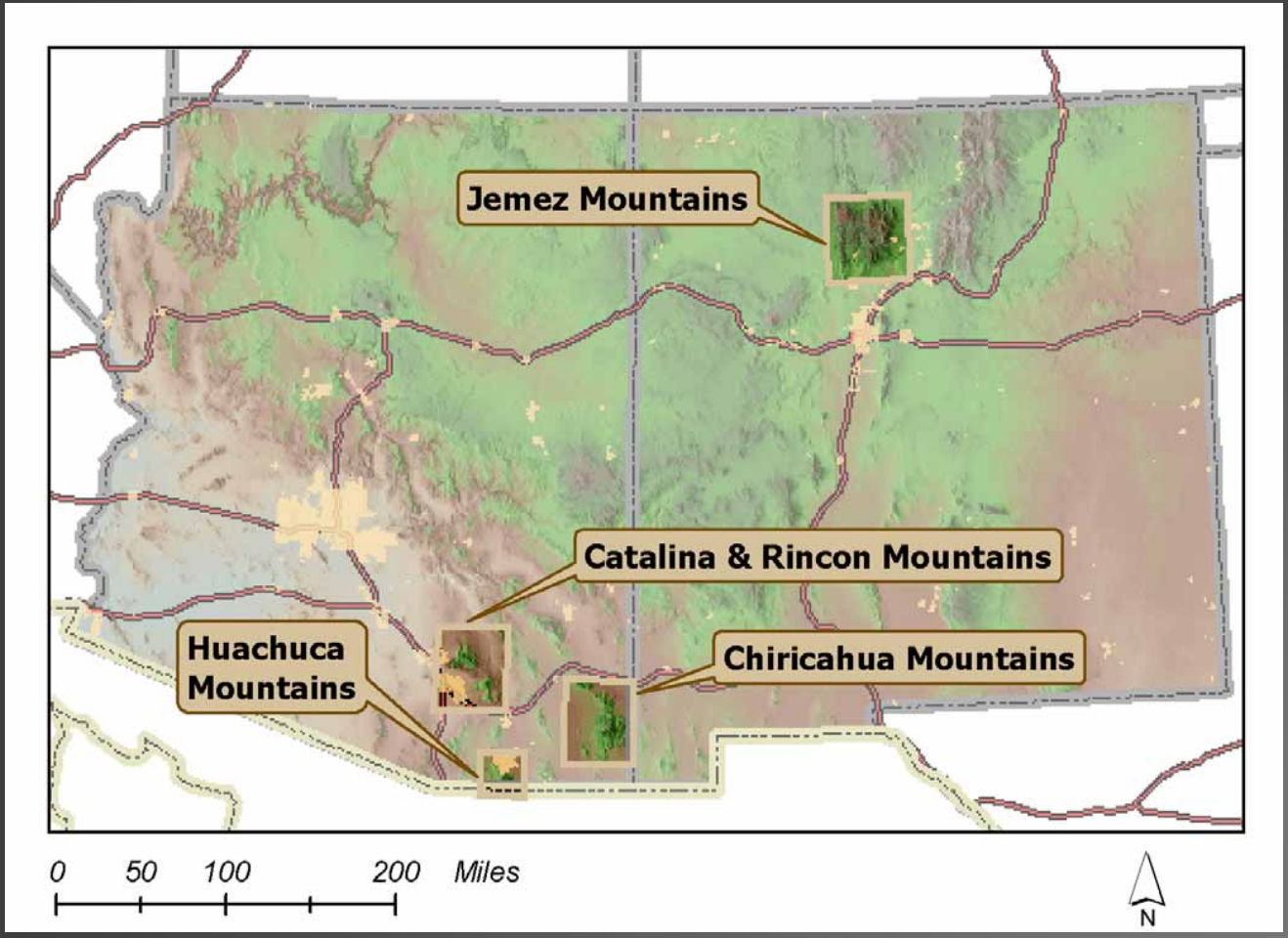
# Model Development

- Integration through interdisciplinarity
  - Remote sensing
  - GIS, fire ecology
  - Fire history
  - Policy
  - Public outreach
  - Climatology
  - Geography
  - Web development & programming

# Model Development (cont'd)

- Collaboration with stakeholders
  - Presentations at fire-climate workshops
  - Evaluation sessions, years 2 and 3
  - Individual interaction with experts
    - Share information/data
    - Discuss techniques/methods

# The Study Areas

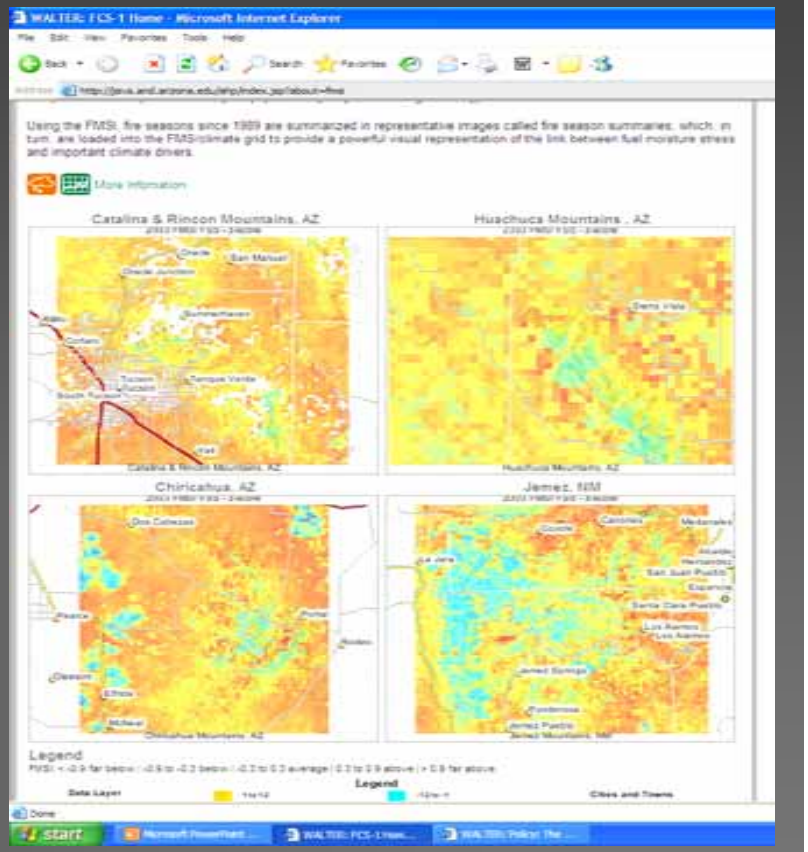


# FCS-1 Components

- 2 sub-models
  - Fire Probability: 5 GIS layers
  - Values at Risk: 4 GIS layers
- 1 km$^2$ resolution

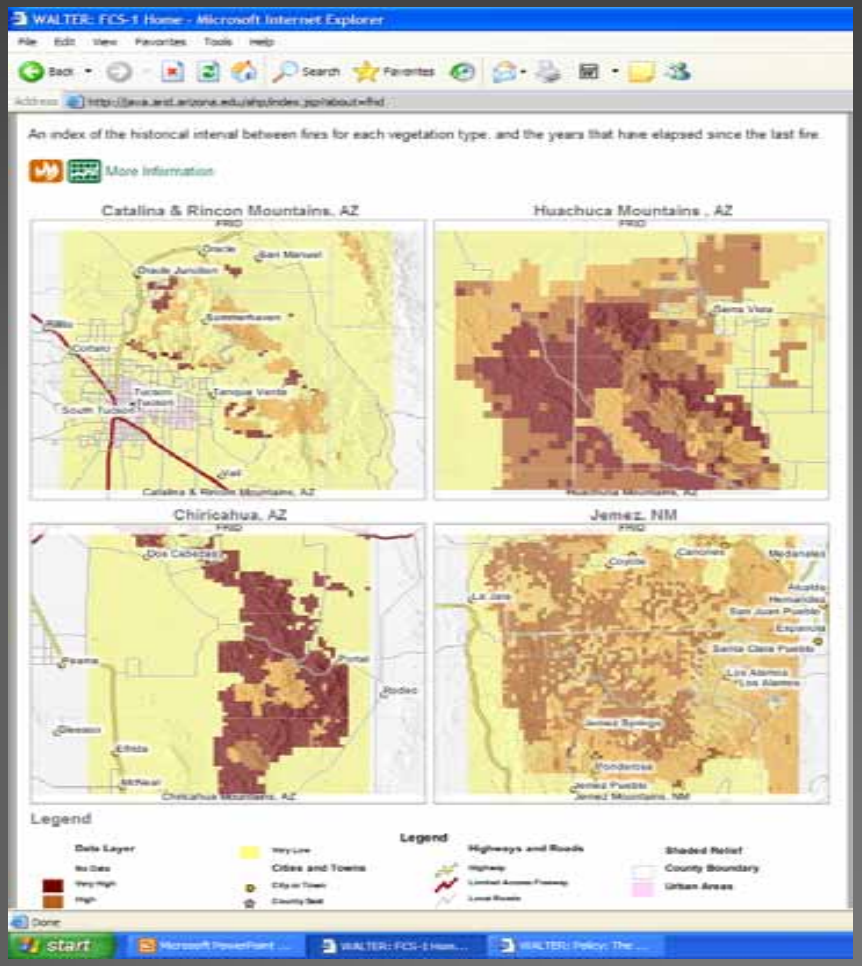
# Fire Probability Sub-Model: Fuel Moisture Stress Index

- Moisture stress level relative to time of year
  - Correlation analysis: interactions between antecedent climate and wildfire variability
  - Relationship: chlorophyll content, live fuel moisture condition, analysis of Normalized Vegetation Index (NDVI) data for fire season
- Fundamental to running FCS-1 climate scenarios
- Influences:
  - Precipitation during previous winter
  - Temperature during spring fire season
  - Degree of dryness during spring and summer seasons



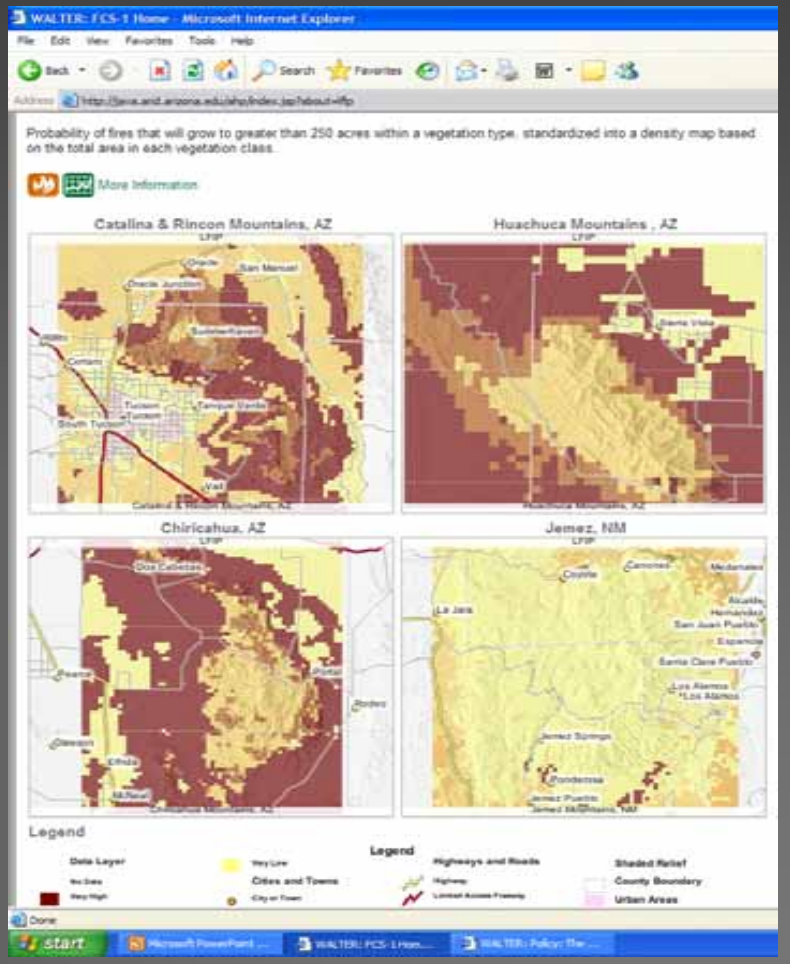
# Fire Probability Sub-Model: Fire Return Interval Departure

- How long it has been since a 1-km pixel has seen fire
  - Relative to how often the area would be expected to burn under natural conditions
- Based on
  - Fire atlases & fire maps
  - Calculation of fire intervals for each vegetation type class
- Formula: FRID Index = (years since last fire – natural fire return interval) / natural fire return interval



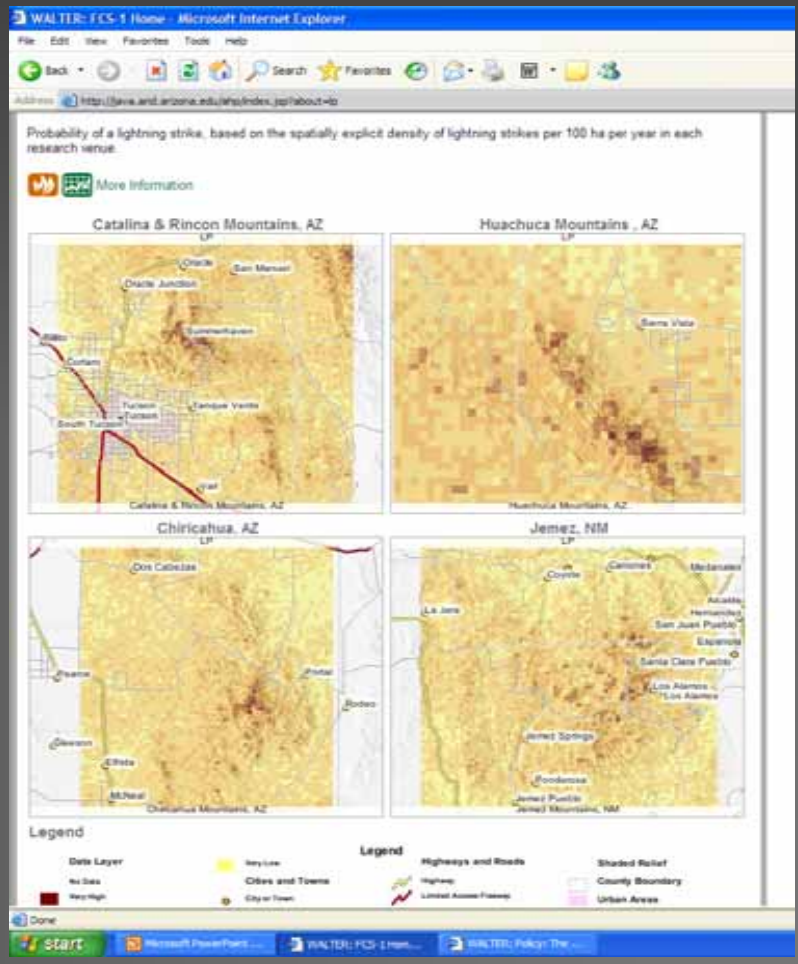
# Fire Probability Sub-Model: Large Fire Ignition Probability

- Statistical probability that an ignition will grow into a "project" fire
  - Fire that exceeds local capability to handle because of its size and/or complexity and thus is turned over to an Incident Management Team
  - Fires >250 ac (101ha) have substantial likelihood to grow into a major wildfire
- Vegetation type assigned to each fire ignition
- Total ignitions per vegetation type standardized into density map based on total area in each class



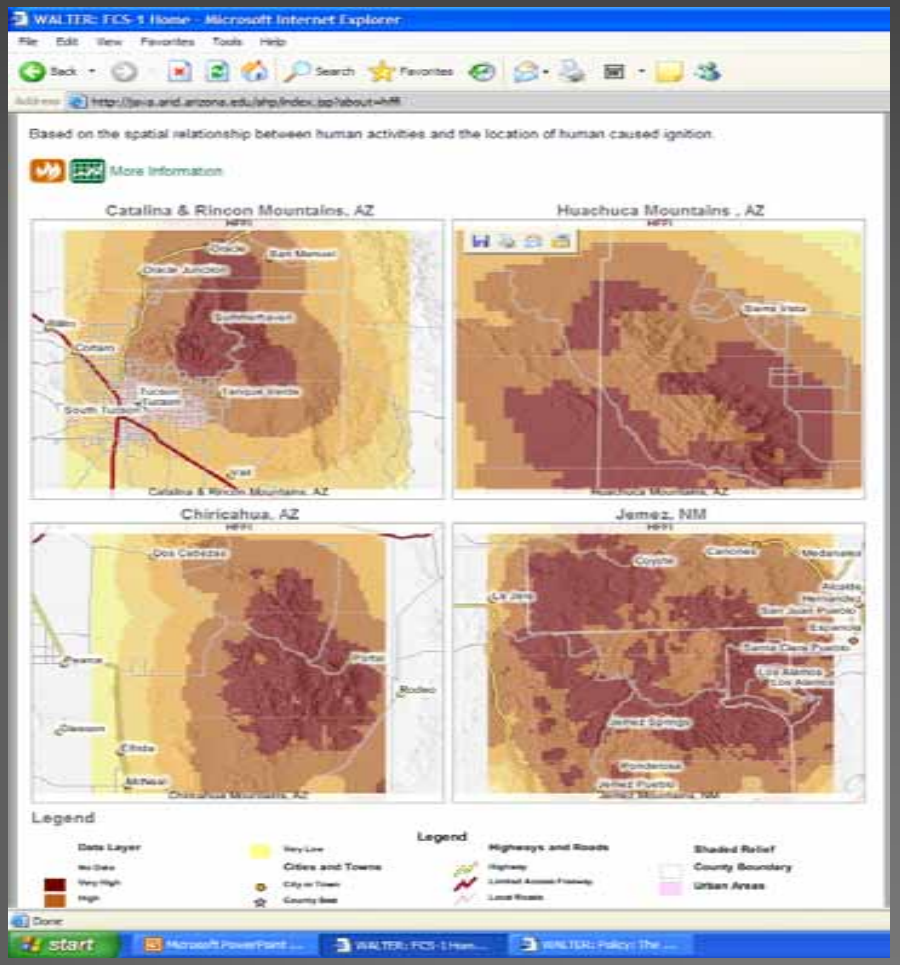
# Fire Probability Sub-Model: Lightning Probability

- Based on lightning data for 1989-1999
  - National Lightning Detection Network ™
- Analysis of density of lightning strikes per 247 acres (100ha) per year per study site
  - Relative probabilities of lighting strikes in one location vs. another proved to remain consistent year to year



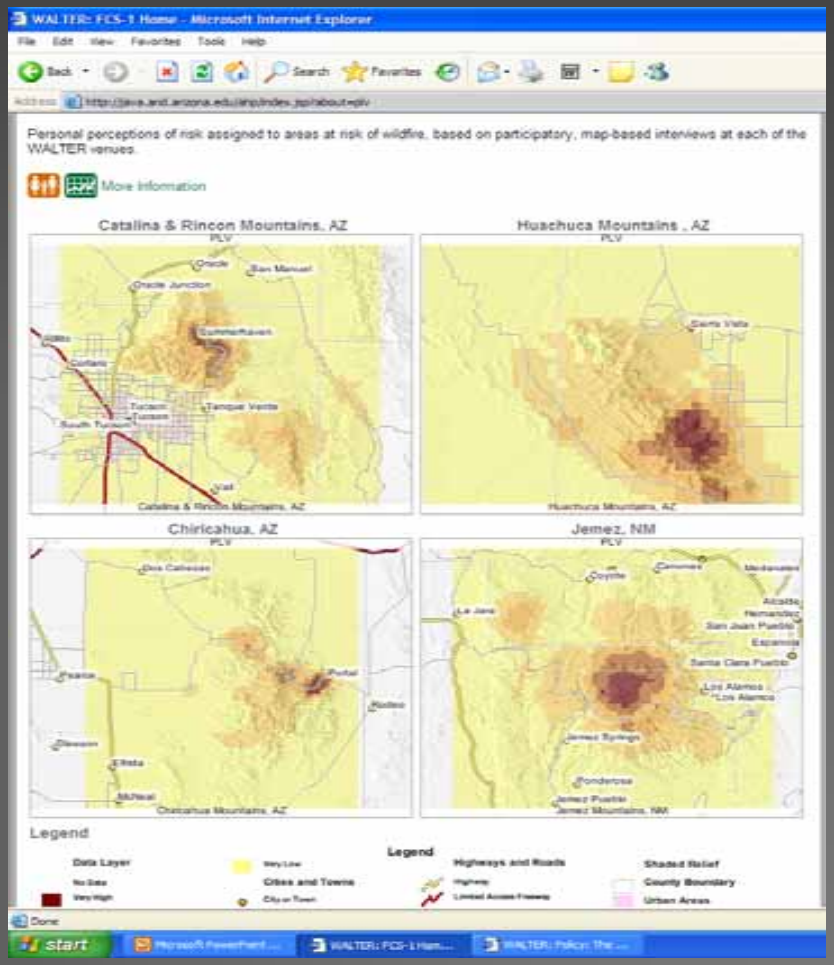
# Fire Probability Sub-Model: Human Factors of Fire Ignition

- Spatial relationship between human activities and locations of human-caused ignitions
- Based on logistic regression analysis
  - Association with proximity to roads, campgrounds & picnic areas, urban areas
    - Human fires tend to occur in non-forested vegetation sites



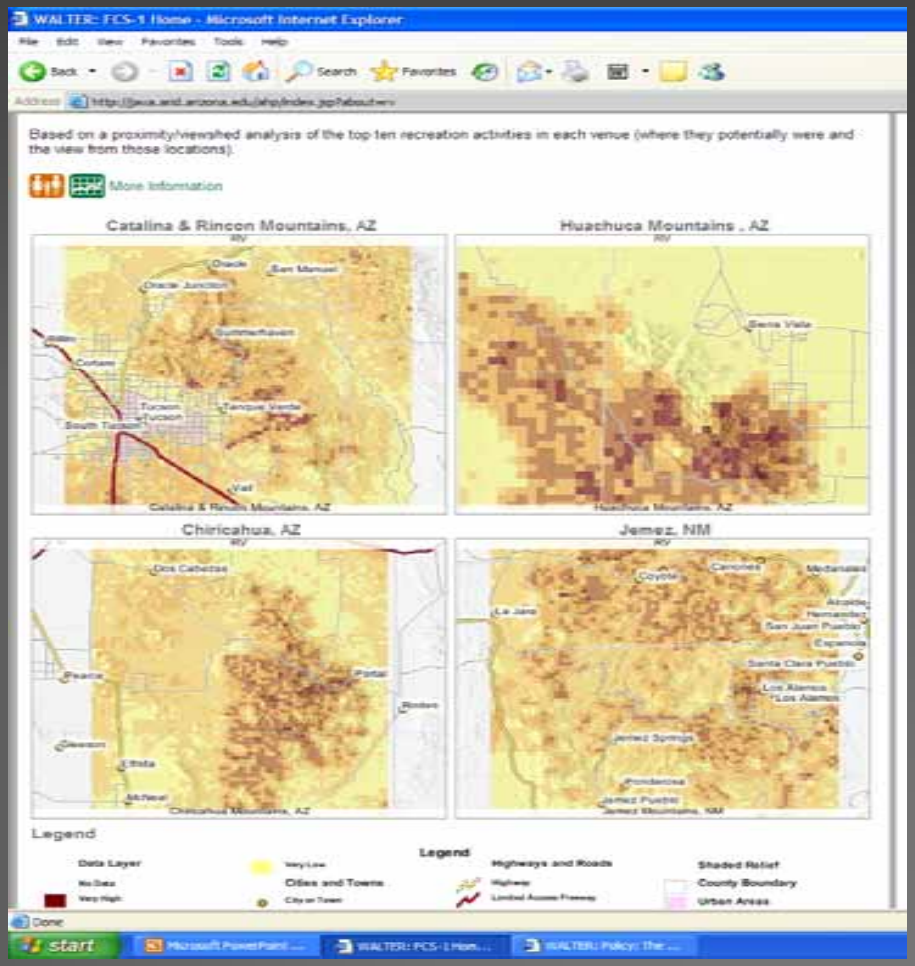
# Values At Risk Sub-Model: Personal Landscape Values

- Values and personal perceptions of risk identified through >100 interviews with individuals in each of the 4 study areas
- Map-marking component
  - Places visited regularly
  - Most likely to burn
  - Most hate to see burn
- Responses were digitized and aggregated to creat this layer



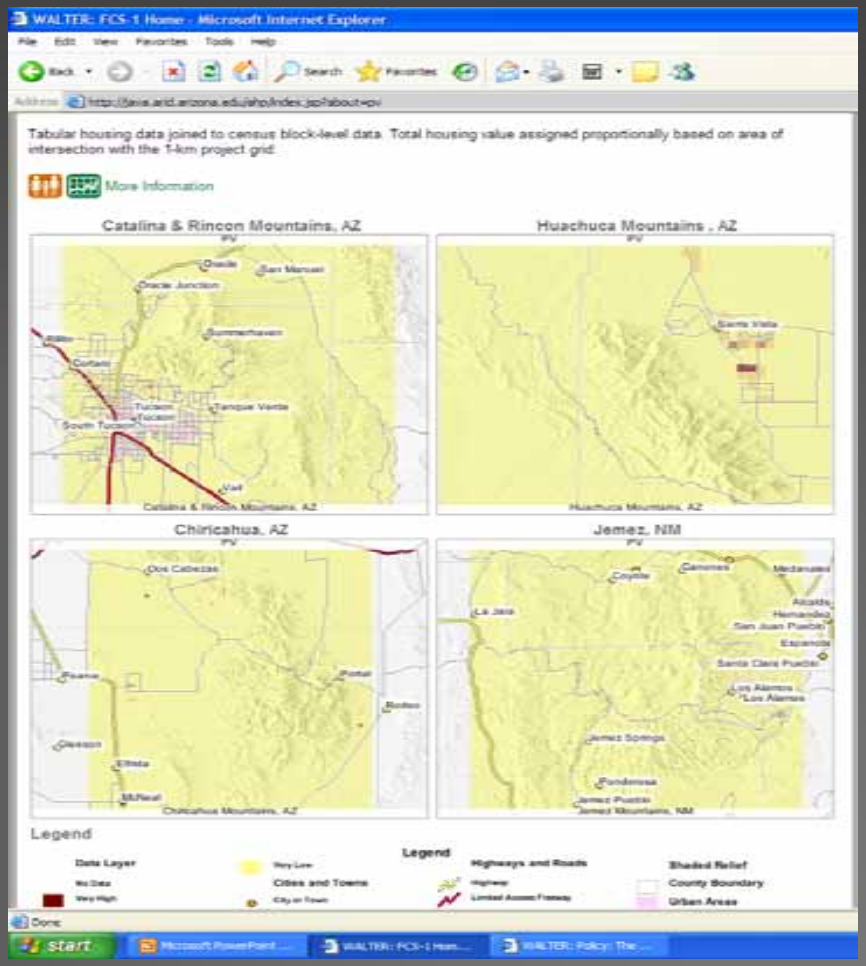
# Values At Risk Sub-Model: Recreation Value

- Recreation one of highest uses of forests in all 4 study areas
- Based on proximity analysis of top ten recreation activities in each venue
  - E.g., campgrounds, hiking trails, lakes, etc.
  - Viewsheds – calculation of Euclidean distance and visibility to features of interest
- Data were weighted by proportion of visitors participating in the top-ten activities then aggregated per 1-km cell



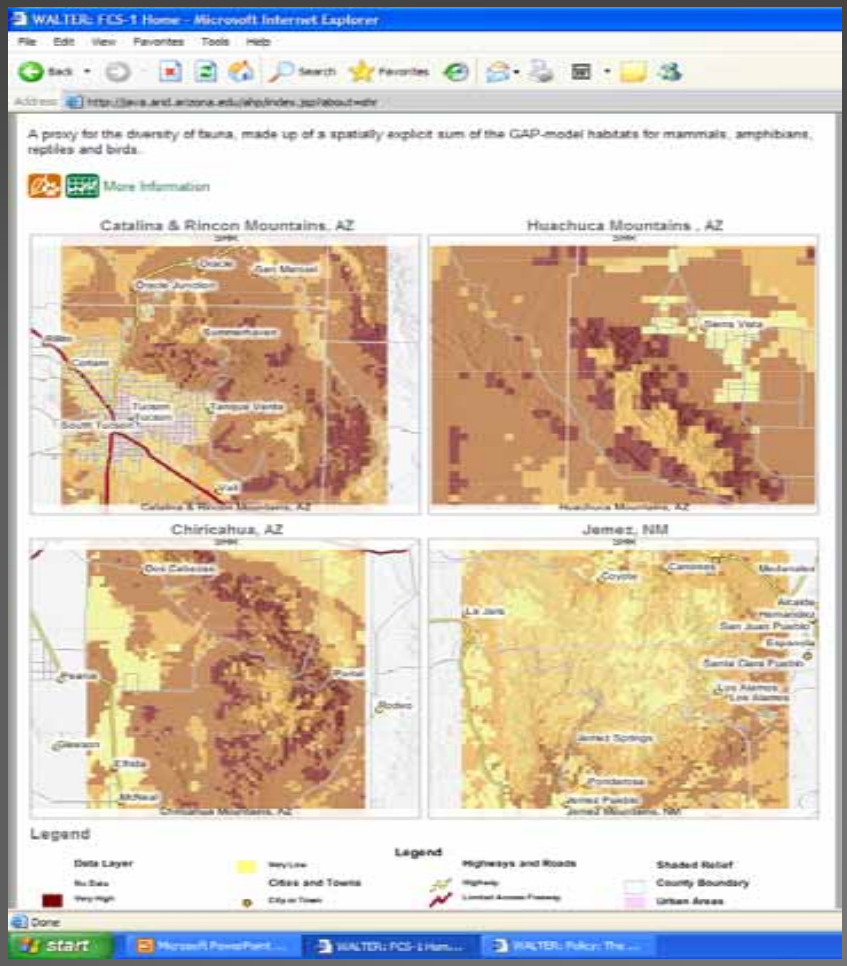
# Values At Risk Sub-Model: Property Value

- Geo-referenced real estate values
  - Tabular housing data combined with census block-level data
  - Total housing value assigned proportionally based on area of intersection with individual 1 km cells
- Serves as proxy for values
  - Placed on being able to live/work near the specified mountain range
  - Monetary values potentially at risk of wildfire



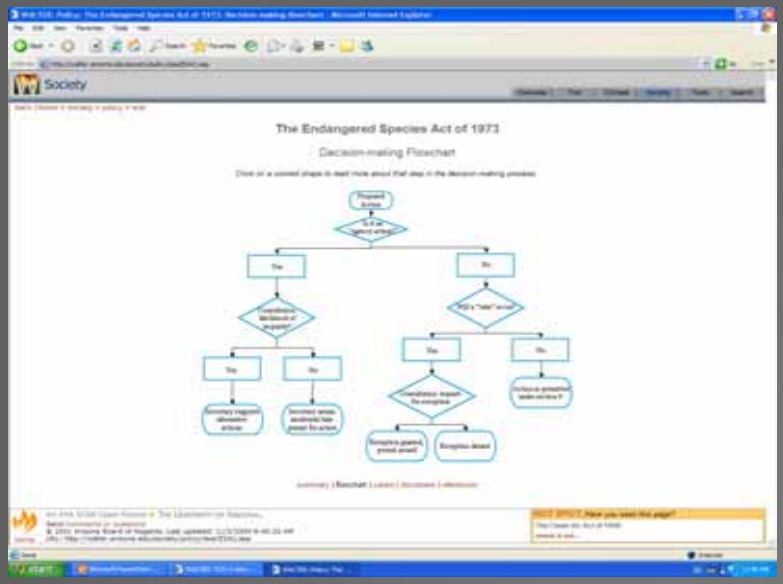
# Values At Risk Sub-Model: Species Habitat Richness

- Proxy for diversity of fauna per 1-km cell
  - By extension, proxy for values people hold about presence of wildlife in the study areas
- Data represent habitat conditions suitable for mammals, amphibians, reptiles and birds that might be expected to visit or reside there
  - Spatially explicit sum of GAP-model habitats
  - No landscape-scale species diversity maps available for the study sites



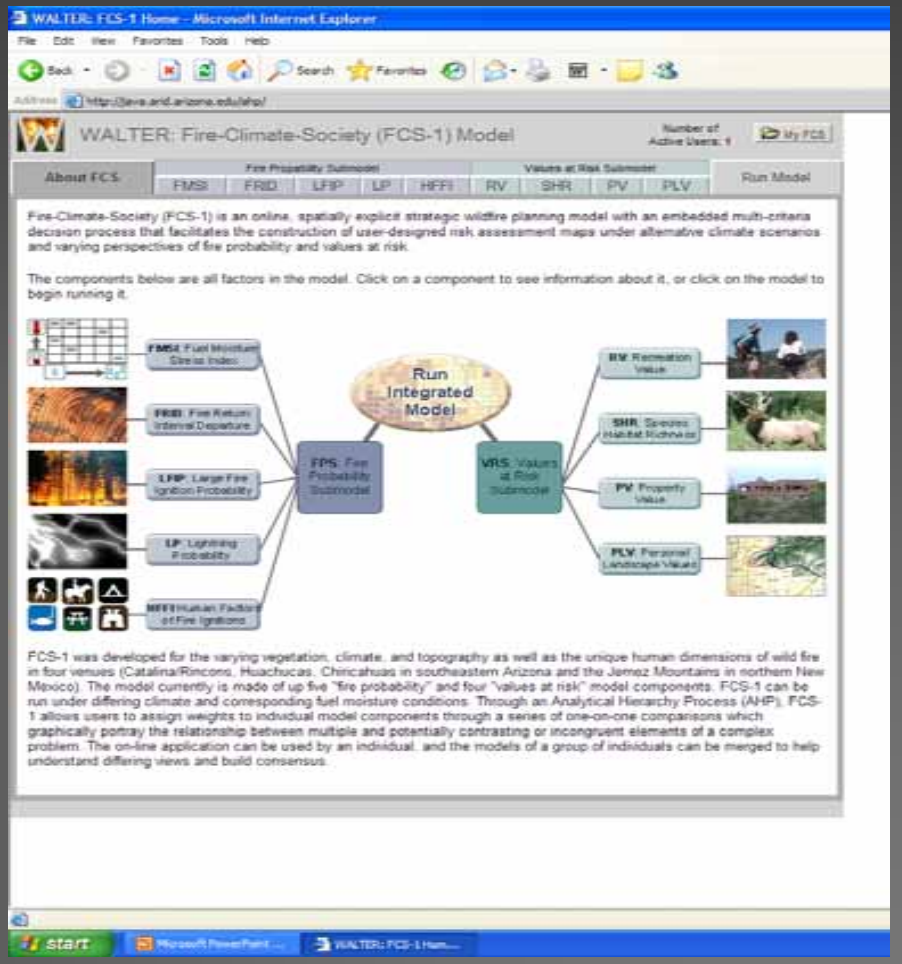
# Wildfire ALTERnatives (WALTER) http://walter.arizona.edu

- FCS-1 model
- Animated NDVI maps
- Fire history maps
- Wildfire-climate regression analyses
- Interactive policy analysis tool

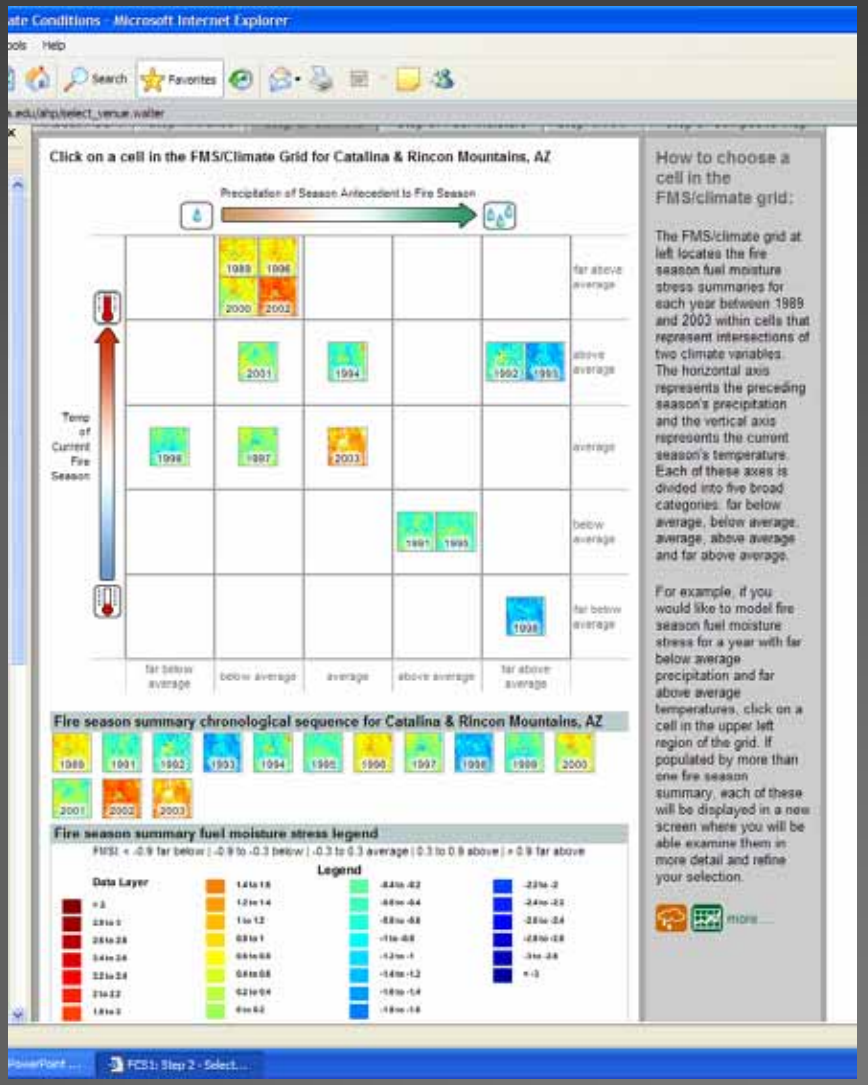
# FCS-1 On WALTER

- User-friendly
  - Access levels for novice, expert
  - Supports individual and group activities
- Flexible



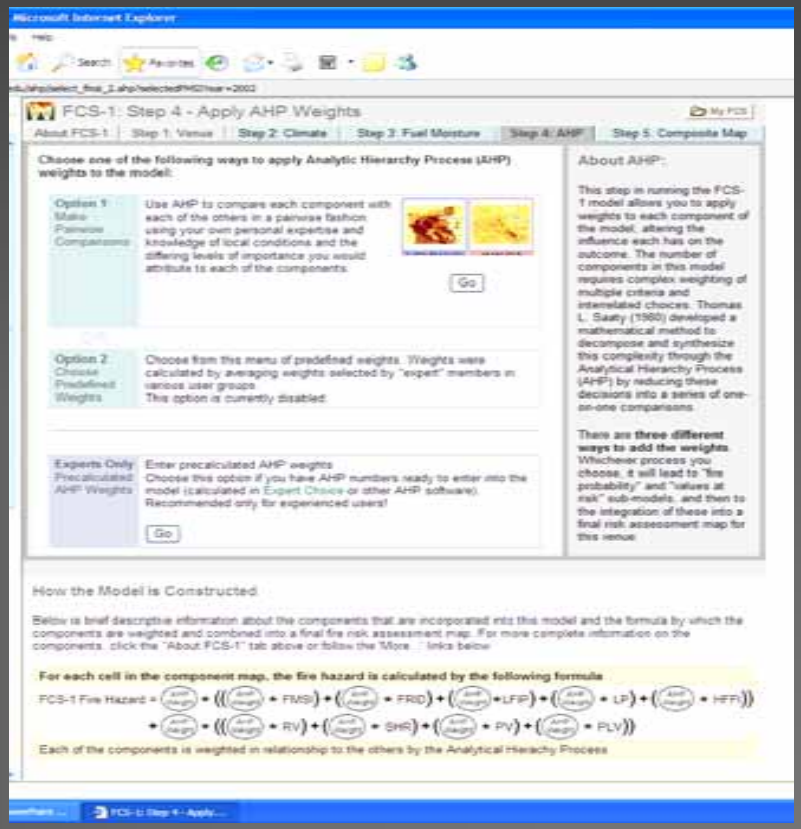
# FCS-1 and Climate

- Model is driven by climate scenarios
- User selects climate profile for selected mountain range
  - Based on 1989-2003
  - Covers extremes in record
    - Very dry to very wet



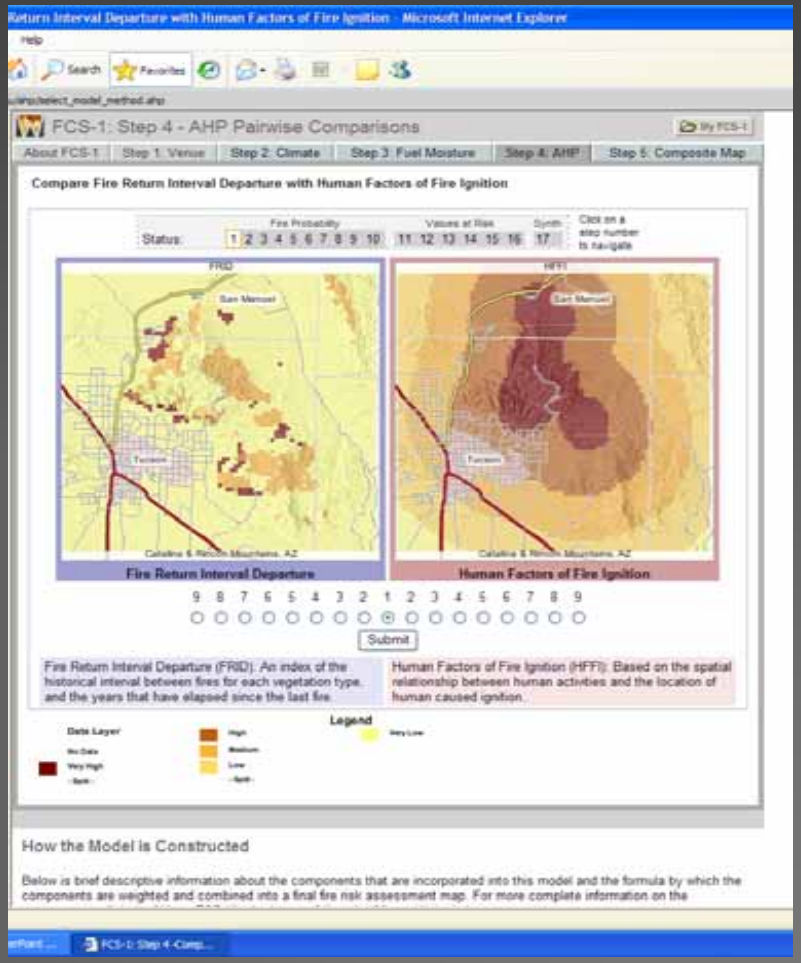
# Weighting Model Layers

- User may choose weight GIS layers
  - Analytic Hierarchy Process (AHP)
- Users may choose predetermined expert weighting scheme
- If authorized, user may input own expert weighting scheme



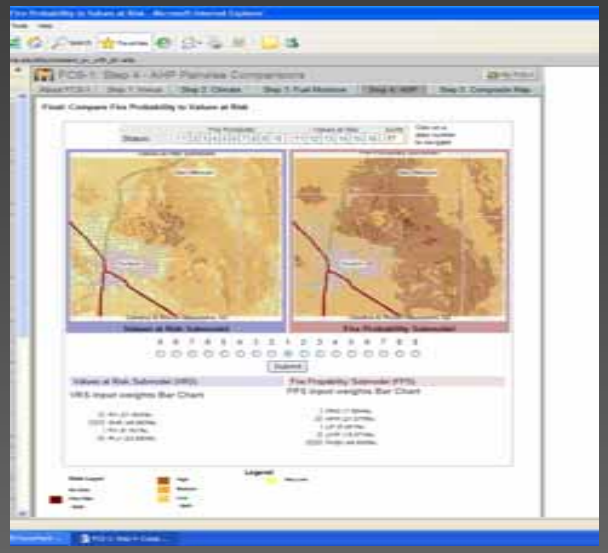
# AHP Process

- Pairwise comparisons
  - Scale 1-9 in each direction
  - If select 1, both are equally weighted
- Weight layers within each submodel
- Weight the two submodels

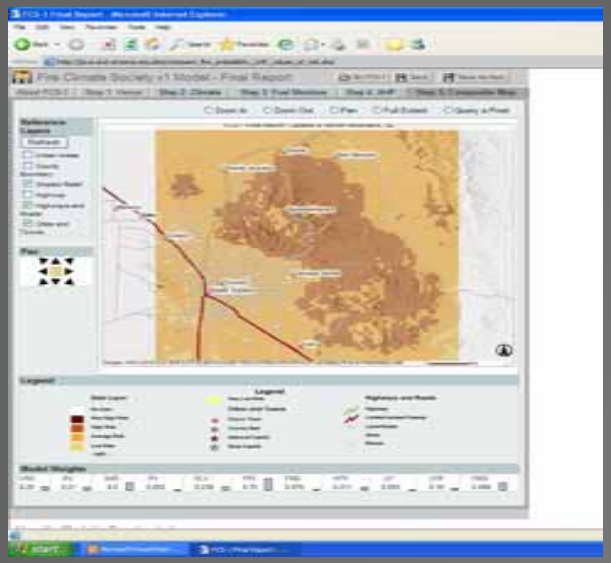


# FCS-1 Fire Risk Maps

- Fire risk map for each submodel



- Fire risk map for integrated model



# Looking to the Future

- Extend to other mountain ranges
- Improve fundamental scientific knowledge
  - Improve model inputs
- Enhance model capabilities (FCS-2…)
  - Smoke emissions, climate forecasts, vegetation dynamics, etc.
- Link to other initiatives
  - Landfire, etc.
- Develop additional decision tools
  - Development scenarios, etc.